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ABSTRACT

Theories of cognitive processing suggest specific effects result from different elaboration treatments. To test this assumption, 125 high school students were randomly assigned to read concept materials containing adjunct elaborations that varied by elaboration type (mnemonics, schematics, or metaphors) and presentation mode (verbal or visual). To permit generalizibility, elaborations were constructed using domain specifications, and treatments were repeated across three subject categories. Post tests revealed that visual mnemonic elaborations are the most effective for higher order comprehension. Compared to a reread-only group, visual schematic and visual metaphors were significantly less effective on tests of recall and comprehension. (Author)

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EFFECTS OF VERBAL AND VISUAL ELABORATIONS ON CONCEPT LEARNING

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INTRODUCTION

Concept learning has been described as an essential educational skill (Bruner, 1969; Gagne, 1977; Klausmeier, 1976). Despite the attention of educators to concept teaching, the abilities of both instructional designers and learners have come under question (Travers, 1970; Markle, 1975; Educational Testing Service, 1978). Criticisms have sparked a renewed interest in underlying mechanisms of concept learning including compensatory strategies that can be given to learners.

It has been suggested that elaborations vary in their power to induce learning of concepts from text (prose material). Information processing theory implies that an abstract concept is learned on a hierarchical continuum consisting of simple recall, rule use, transfer, and generation capability. Research in prose organization and learning suggests that mnemonic strategies are used to aid recall, schematics (formulas and algorithyms) are used to aid rule use and application, and metaphorical elaboration provides additional practice in application and transfer skills. Similarly, initial imagery research indicates that images supply information at varying degrees of abstraction in a diversity of contexts. The reported findings in prose organization and imagery prompts inquiry into the effects of systematic variation of verbal and visual elaborations.

Research has suggested that the use of adjunct organizers influence attention to and selection of materials as well as learner recall, comprehension and transfer skills (Ausubel, 1963; Wittrock, 1977; Rothkopf, 1967). Work by Keislar and McNeil (1962), Wittrock (1976), Pavlo (1971), Rohwer (1975), Levin (1976), Pressley (1977), Tennyson (1978), among others, indicates that images (both imposed

and induced) have positive effects on learning to read and understand concepts. However, several questions remain. The purpose of the study was to find out:

1. If text material is held constant and treatment elaborations are allowed to vary systematically, will there be differing effects on recall and comprehension of conceptual materials?

2. How does presentation mode (verbal and visual) influence the learning of concepts?

3. What types of elaboration effects generalize over subject matter? In particular, how do elaborations affect the learning of relational material in science, social science, and humanity disciplines of high school-level curriculum?

RATIONALE

Mnemonics, Schematics and Metaphors were selected as elaboration categories because they represent learning strategies that varied in difficulty and level of abstraction, yet all claimed to aid understanding through simplification. The selection of concepts to be taught was restricted to defined concepts at the tenth grade level or above.

The research on verbal/visual processing would suggest that either verbal or visual elaborations would be more effective in inducing comprehension and retention of original exposition material in contrast with additional rehearsal of the material. The literature (Gagne, 1974; Rohwer, 1975; Pressley, 1977) indicates that information is learned more efficiently when a structural grounding of context for meaning is provided.

Systematic differences in effectiveness were predicted to exist among mnemonic, schematic, and metaphorical elaborations. The metaphor category would seem most likely to facilitate comprehension and transfer effects because the process of comprehending a metaphor forces one to inspect and to detect relevant and ir-

relevant features from an item (Davis, 1976; Otony, 1977). This ability has been described as an important aspect of concept learning and rule application (Travers, 1970; Gagne, 1974; Klausmeier, 1974; Markle, 1975). Despite these qualities, metaphors also have the highest risk of the three methods of elaboration, in that the initial comprehension problems could misdirect the learner.

Schematics were predicted to have less of an effect on transfer. Travers' study (1970) points to possible hazards in attempting to simplify material. The elimination of irrlevant inputs may increase content knowledge yet at the same time interfere with the ability to apply concepts in new situations. The category of schematics attempts to alter presentation material by simplification.

Mnemonic devices, unlike schematics and metaphors, are the least concerned with rearrangement of the meaning of the material and most concerned with enhancing the ability to reproduce the content as given. The prediction was that mnemonics are more effective for recall and retention than for higher order comprehension capability. Mnemonics would be the least useful for inducing alternative ways of viewing information but they would be predicted to reinforce knowing the material as presented. Therefore, one could expect mnemonics to be least effective in producing content-concept interactions. At the same time they offer the least potential for confusion in that area.

RESEARCH DESIGN

To test the main hypothesis of the study, a three by two factorial design was developed. There were three types of treatment elaborations: 1) mnemonics, 2) schematics, and 3) metaphors. Each elaboration was presented in a: a) verbal and b) visual mode for a total of six elaboration treatments. There was also one reading only treatment condition for a total of seven groups. Each individual

was assigned to only one treatment condition to permit aggregation across concept types and use of repeated measures analysis (Glass, 1970). The criterion measures includes participant performance on an immediate post test of recall and comprehension.

POPULATION

The study was carried out with one hundred thirty tenth and eleventh grade students. Tenth and eleventh grade levels were chosen for a number of reasons: 1) at this level the range of defined concepts that can be sampled is great; 2) however, the students would not have been exposed to all high school concepts because they are at the high school lower grade levels; 3) developmentally, verbal and visual ability of students should have reached maturity.

SAMPLING

Students in intact classrooms were randomly assigned to one of the six elaboration treatment or read only treatment conditions groups in six Social Studies and English classrooms. Social studies and English classes are requirements for all students in those grades, permitting a random sample of all possible students.

TREATMENTS CONDITIONS

There were six different experimental conditions plus one read only group. The concepts to be taught were restricted to relational (defined concepts) presented by means of a definition and one example. Each participant was taught three concepts according to the treatment assigned to that group. For each concept, the subject first read a standard one hundred to one hundred fifty word passage explaining the concept. This passage was the same for all seven groups.

Independent Variables

The independent variables are verbal and visual elaborations to prose matarial each presented in one of three ways: 1) mnemonics, 2) metaphors, or 3) schematics. In addition, the control group reread original material. Mnemonics, metaphors and schematics are used with the common goal of trying to increase understanding through elaboration. The process involved in generating and decoding these elaborations provides the distinctions between the categories.

Description of Elaboration

Metaphors serve as comparisons. The metaphor achieves its purpose by illustrating the congruence of seemingly dissimilar objects and events. The metaphor has differing degrees of abstractness depending upon the context, the concreteness of comparisons, and the familiarity of the learner with critical features of the metaphor. Schematics differ from metaphors in that they do not attempt comparisons but rather attempt to organize material by emphasizing and explicating salient features. A schematic tries to simplify the information or concept into key parts or variables. The level of abstraction is a function of the complexity of the arrangements or orders.

A mnemonic device is a type of elaboration used to increase learning of a concept through the use of memory strategies and plans. Although schematics or metaphors might serve a mnemonic function that they increase learning, for this study mnemonics were restricted to those strategies that attempt only to increase learning of material and not systematically alter the perceptions or organization of content material itself.

Each of the elaborations described was cast into verbal and visual treatments. Verbal treatments were defined as prose presentations only. Visual treat-

ments refer to diagrammatic or representational pictures or presentation of prose in a spatial arrangement, e.g., flow charts.

DEPENDENT MEASURES

The categories of dependent measures included 1) recall - multiple choice questions; 2) higher order comprehension - multiple choice questions; and 3) a picture production question.

The recall related questions asked for descriptive information and definitions. The comprehension task called for the classification of examples of the concept. The picture production question required the students to draw a picture of the concept presented.

For each concept presented, students were required to answer two recall questions, two higher order comprehension questions, and one picture production question. Each student read three concepts (concerning osmosis, monopoly and syllogisms) and thus answered a total of fifteen questions. The questions were devised following the preparation of domain specifications. The items were prepared before construction of the treatment elaborations in order that bias toward any one method would be assessed. Items were submitted to rates to judge difficulty and validity based on specifications.

INSTRUMENTS AND MATERIALS

Works of Hively (1974); Baker (1974); and Anderson (1973) suggested that the use of rules and domain specifications facilitate instructional designs. Domain descriptions clarify by establishing content limits, stimulus response characteristics and format regulations. As described in the previous section, domain specifications allow for broader generality of results by providing operational definitions.

Domain specifications were used for development of the concepts, elaborations and post test questions. A review of abstract concepts taught in the 10-11th grade curriculum was conducted using representative texts and cirricula frameworks from the State of California (1975).

For each concept chosen, a definition example and set of key words relating to the concept were developed using a dictionary and other reference materials. The definition included the relationship that exists among the sub-topics. Key words and synonyms were restricted to those that are at grade level or lower equivalence (tenth and eleventh grade). The definition and key words served as the common pool of information for the development of the six elaboration treatments.

RESULTS

The dependent measures were first analyzed by combining the scores for each participant across the three concepts presented. The scores represent total comprehension (lower order recall and higher order comprehension questions) on a twelve point scale. Table 1 summarizes the scores by elaboration category (mnemonics, schematics and metaphors). Significant differences were found between elaboration categories, $F(2,107) = 4.86$ $p < .01$. Post hoc comparisons indicated that scores in the category of mnemonics were significantly higher than either schematic or metaphor elaborations.

Comparison scores were divided into lower order and higher order questions. Analysis of variance revealed no significant differences among elaboration categories for lower order questions. Significant differences were found among elaboration categories for higher order questions, $F(2,107) = 5.61$ $p < .003$. (See Table 1). Comparisons between the elaboration categories and the reread group

indicated one significant difference. The category of metaphors was significantly lower than the reread only category.

Elaboration Treatments and Comprehension

The seven treatment conditions included the three elaboration categories divided into verbal and visual modalities (verbal mnemonics, visual mnemonics, verbal schematics, visual schematics, verbal metaphors, visual metaphors) and the reread only condition. Total comprehension scores were analyzed to compare the seven treatments. Table 2 summarizes the data and reports significant between group differences $F(6,117) = 2.46$ $p < .02$. Post hoc comparisons indicated that scores in the visual mnemonic and reread only categories were significantly higher than the visual schematic group and both the verbal and visual metaphor categories.

Table 3 summarizes higher order comprehension questions for the seven treatment conditions. No differences were found between groups on lower order comprehension questions. There were significant differences between groups on higher order questions $F(6,117) = 3.19$ $p < .006$.

Effects Due to Presentation Modality

No differences were found when the three verbal treatments and three visual treatments were compared. In addition, no significant interactions occurred between treatment category (Mnemonic, Schematic and Metaphor) and presentation mode verbal and visual. It is of interest to note that the highest and lowest scores were both in the visual elaboration category (Table 2).

PICTURE PRODUCTION QUESTIONS

Picture production was evaluated by two methods. The first method, picture one, credited participants for any picture produced. The second method, picture two,

required incorporation of some aspects of the elaboration for credit.

Picture one results indicated no between group differences. However, there were significant differences between treatment modalities. The visual modality group produced significantly more pictures than the verbal modality group.

In the picture two condition (pictures matching elaborations) there were significant differences between elaboration type, presentation modality and the interaction of each. More pictures were produced by the visual modality group $F(1,102) = 8.28$ $p < .02$. The metaphor category produced the most pictures $F(2,102) = 4.39$ $p < .02$.

The results suggest that a visual elaboration is an effective prompt for immediate recall of an elaboration strategy. Whether the prompt helps or detracts from learning is of course another question to be discussed in the next section. The significant difference between pictures produced in the verbal vs visual elaboration strategies further indicates that the participants were "giving attention" to the visual stimuli in the elaborations presented.

Repeated Measures Design

After the initial analaysis, the study was rerun using repeated measures analysis of variance (UCLA Biomedical Program Number Two). Analysis was conducted to determine effects of methods, concepts presented, and participant variation, and the interaction of each on total comprehension. Table 4 summarizes the results. Significant differences were found between concepts $F = 8.46$ $p < .005$, participants, $F = 3.22$ $p < .001$, methods $F = 2.63$ $p < .05$ and the interaction of concept and method $F = 1.94$ $p < .03$.

Mnemonic elaboration scores ranked highest for each concept, followed by schematic and metaphor elaborations.

DISCUSSION AND CONCLUSIONS

The results of this study suggest that verbal and visual elaborations can differentially affect the learning of concepts. The facts that the concept material presented was brief, that the exposure to the elaboration was for a short duration and that no prior training was required, should be of interest to educators. The implication is that subtle changes in the elaboration of standard materials may have direct impact on learner's ability to derive meaning from texts.

The results of particular interest center around the differences among the elaboration categories on the higher order comprehension tests. The predictions that metaphors would provide the most assistance with higher order questions was wrong. Another result, indicating that mnemonic elaborations had the greatest effect on higher order comprehension, also contradicted the forecasts. A rationale for the results has been partially suggested in the justification of the independent variables. It was stated that metaphors and mnemonics differed in the way each strategy organized information. A metaphor elaboration required students to learn a new context for a concept, whereas a mnemonic only required reassociation of original material. The metaphor category thus had the highest potential for causing misunderstanding on the part of the learner.

The results also may be analyzed by referring to the principle that new conceptual information "takes time" to encode. This has been suggested by the literature describing the effectiveness of examples and additional rehearsal information (Travers, 1970; Anderson and Faust, 1973). It is postulated that if a student is asked to inspect or perform a transformation of the information before it has been fully encoded, the learner's original data base (memory) may suffer disorientation or be distracted. It is significant to note that the mnemonic elabora-

tions were operationalized to link the concept and definition but required no transformation of data to a new context.

Differential effects were also found in the study when the use of visual elaborations is isolated. Visual mnemonics and visual schematics were the most and least successful strategies respectively. This would suggest that the use of categorical term pictures or visuals is too vague and will not permit prediction of instructional effect. As Arheim (1969) suggests, visual information appears to have varying degrees of abstractness requiring different levels of learner sophistication for comprehension. This assertion cannot be directly supported by this study, however, for the learner's understanding of the visual or verbal elaboration was not directly assessed.

The picture production results suggest that memory of an elaboration and ability to reproduce the scene, does not necessarily imply that the picture was comprehended as intended nor does it facilitate learning as measured by the post test (e.g., a student may remember a picture of an octupus linked with the concept monopoly but never understand the connection of octupus to the coordinate concepts of control and ownership). Indeed, more pictures were produced in the visual metaphor category than in the visual mnemonic category yet comprehension scores were in reverse.

Information Processing Theory

The two important findings discussed (the relative effectiveness of mnemonics on higher order comprehension, and the differential effects of visual elaborations) can both be analyzed in the context of the current debates of information processing theory.

Kieras (1978) has outlined the competing theories of imagery storage in memory. The different positions range across the continuum from postulations that

all input is assigned in memory as visual stimuli to the contention that input is expressed "in a single uniform abstract type of representation - the proposition." (p. 533). While it is widely accepted that images do provide perceptual information that differs from verbal information, the controversy is centered around how an image is encoded and retrieved. Kieras asserts that the most evidence can be cited for the stored image model-imaginal elaboration. In this model "redundant connections are provided by perceptual relations that interconnect the concepts" (p. 545). The fact that the participants in the present study were able to reproduce elaborations visually, and that there were differences between the treatments groups (e.g., the depressing effects of visual schematics and metaphors when compared to the reread and visual mnemonic group) tend to lend support to the theory that visual presentations are encoded differently from verbal presentations and that the verbal and visual propositions interact at a deep processing level.

Implications For Further Research

The present study suggests that mnemonic strategies have positive effects upon abstract concept learning. This finding follows the line of inquiry (Higbee, 1978; Johnson, 1980) reporting a wider role for mnemonics in higher order learning tasks. The study also conforms to the research that warns that metaphor comprehension is a requiring practice with inferential learning and is therefore more difficult.

The finding that visual mnemonics elaborations were the most effective treatment strategy should be examined with reference to memory storage theories. Andre (1979) discusses the differences between episodic and semantic memory originally proposed by Tulving (1972). Episodic memory "contains memories for the personal stream of events encountered by the information processor. . . organized

sptially/temporally." Conversely, semantic memory contains "generalized knowledge . . . concepts principles . . . rules broader than specific episodes." (p. 304). Using these schema as a guideline, learning can be defined as making the transition from episodic cuing (of particulars) to semantic processing (of universals). Storage and retrieval are the interaction of episodic and semantic networks. Amnemonic elaboration then, may be described as a mechanism that permits additional cuing for episodic memory. Or, in other words, the mnemonic holds the particular components of a concept (the definition and key words) together and eases access into semantic memory. Andre speculates that the effect of imagery on higher order learning would be to assist episodic memory and thus indirectly influence semantic learning (p. 313).

Thus, combining the theories on image processing and memory storage, one may speculate that the elaboration differences (specifically visual mnemonics elaboration success) is explained by the redundant connection hypothesis and the episodic memory cuing hypothesis. The visual metaphor and schematic categories also supplied redundant information but unlike mnemonics interfered with memory storage by distracting the original semantic input that could be recalled. Students were not asked until the post test to draw a picture to help remember the concept. In the visual elaboration groups, pictures were imposed upon participants as a memory aid. Research in imagery (Pressley, 1977; Wittrock, 1979; Levin, 1976) suggests that instructions that require students to form an image or generate a picture have also been successful for improving comprehension. While the present study was limited to imposed pictures to control elaboration effects, an alternative design could be developed to test effects of imposed vs induced imagery elaboration treatments.

To summarize, curriculum designers face the difficult task of preparing materials at different degrees of specificity and for heterogenous set of learners. This study suggests that brief elaborations vary widely in their power to influence learning. Caution should be given to the use of an elaboration selected without testing the effects on learners. While many strategies can be justified on the basis of simplification, clarification, or additional practice, few may survive empirical investigation. Students may benefit from or be distracted by relatively small modifications in instructional materials.

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TABLE 1

Treatment Elaborations, Presentation Mode Dependent Measures - Marginal Means

	Total Comprehension	Lower Order Comprehension	Higher Order Comprehension	Picture Production Any Picture	Picture Production Matching Elaboration	Affect
Mnemonics N = 36	$\bar{x}$ = 7.05 sd = 2.54	$\bar{x}$ = 3.86 sd = 1.53	$\bar{x}$ = 3.19 sd = 1.44	$\bar{x}$ = 1.83 sd = 1.25	$\bar{x}$ = .72 sd = 1.08	$\bar{x}$ = 6.30 sd = 2.45
Schematics N = 35	$\bar{x}$ = 5.74 sd = 2.30	$\bar{x}$ = 3.48 sd = 1.31	$\bar{x}$ = 2.25 sd = 1.48	$\bar{x}$ = 2.25 sd = 1.17	$\bar{x}$ = 1.42 sd = 1.20	$\bar{x}$ = 5.42 sd = 2.3
Metaphors N = 37	$\bar{x}$ = 5.24 sd = 2.81	$\bar{x}$ = 3.18 sd = 1.63	$\bar{x}$ = 2.05 sd = 1.59	$\bar{x}$ = 2.00 sd = 1.17	$\bar{x}$ = 1.29 sd = 1.22	$\bar{x}$ = 5.27 sd = 2.50
Verbal Elaborations N = 54	$\bar{x}$ = 6.1 sd = 2.65	$\bar{x}$ = 3.48 sd = 1.55	$\bar{x}$ = 2.62 sd = 1.45	$\bar{x}$ = 1.75 sd = 1.27	$\bar{x}$ = .85 sd = 1.09	$\bar{x}$ = 5.64 sd = 2.45
Visual Elaborations N = 54	$\bar{x}$ = 5.90 sd = 2.70	$\bar{x}$ = 3.53 sd = 1.48	$\bar{x}$ = 2.37 sd = 1.66	$\bar{x}$ = 2.27 sd = 1.05	$\bar{x}$ = 1.44 sd = 1.29	$\bar{x}$ = 5.68 sd = 2.56
All Elaborations N = 108	$\bar{x}$ = 6.00 sd = 2.67	$\bar{x}$ = 3.50 sd = 1.50	$\bar{x}$ = 2.5 sd = 1.5	$\bar{x}$ = 2.02 sd = 1.19	$\bar{x}$ = 1.14 sd = 1.20	$\bar{x}$ = 5.60 sd = 2.47
Control N = 16	$\bar{x}$ = 6.62 sd = 2.03	$\bar{x}$ = 3.81 sd = 1.31	$\bar{x}$ = 2.81 sd = 1.40	$\bar{x}$ = 2.13 sd = 1.20	-	$\bar{x}$ = 6.12 sd = 1.96

TABLE 2

Lower and Higher Order Comprehension
Analysis of Variance

CODE	VALUE LABEL	MEAN	STD DEV	N
1.	Verbal Mnemonic	6.7647	2.3856	17
2.	Verbal Schematic	6.5000	2.2816	18
3.	Verbal Metaphor	5.1579	3.0416	19
4.	Visual Mnemonic	7.3158	2.7091	19
5.	Visual Schematic	4.9412	2.2212	17
6.	Visual Metaphor	5.3333	2.6346	18
7.	Reread Only	6.6250	2.0290	16
Within Groups Total		6.0887	2.5096	124

SOURCE	SUM OF SQUARES	D.F.	MEAN SQUARE	F	SIG.
Between Groups	93.143	6	15.524	2.465	0.0279

TABLE 3

Higher Order Comprehension
Analysis of Variance

CODE	VALUE LABEL	MEAN	STD DEV	N
1.	Verbal Mnemonic	3.0000	1.3229	17
2.	Verbal Schematic	2.8333	1.3827	18
3.	Verbal Metaphor	2.1053	1.6294	19
4.	Visual Mnemonic	3.3684	1.5352	19
5.	Visual Schematic	1.6471	1.3666	17
6.	Visual Metaphor	2.0000	1.6088	18
7.	Reread Only	2.8125	1.4245	16
Within Groups Total		2.5403	1.4764	124

Analysis of Variance

	SUM OF SQUARES	D.F.	MEAN SQUARE	F	SIG.
Between Groups	41.768	6	6.961	3.194	0.0061

TABLE 4

Repeated Measures Design
Analysis of Variance for Dependent Variable I

	Source	Error Term	Sum of Squares	D.F.	Mean Square	F	Prob.
1	Mean		1462.503	1	1462.50290	-	-
2	Methods		31.893	6	5.31548	2.63	.05
3	Concepts	MP	20.577	2	10.28869	8.46	0.0051
4	Subjects	SP (M)	211.937	105	2.01845	3.22	0.0000
5	Subjects & Concepts	SP (M)	14.539	12	1.21577	1.94	0.0312
6	Residual		131.500	210	0.62619	-	-

Estimates of Variance Components

(1)	4.30986
(2)	0.05641
(3)	0.08101
(4)	0.46409
(5)	0.03685
(6)	0.62619